

**CLAIMS:**

1. A method of controlling the operation of a pulsatile heart assist device in a patient, consisting of utilising sounds produced by the heart to control the operation of the heart assist device.
- 5 2. The method as claimed in claim 1, wherein the method uses a combination of R-wave detection and heart sound detection to control the operation of the heart assist device.
3. The method as claimed in claim 1, wherein the heart assist device is completely controlled by utilising both the S1 and S2 sounds of the heart to both stop and start the  
10 heart assist device.
4. A method of controlling the operation of a pulsatile heart assist device in a patient, consisting of electrically detecting the R-wave of the patient's heart rhythm and producing a signal to initiate a change in the pulsatile status of the heart assist device, and detecting a sound or pressure wave created by the closure of the patient's aortic valve and  
15 producing a signal to return the heart assist device to the pulsatile status it had before the preceding R-wave.
5. A method of controlling the operation of a pulsatile heart assist device with a multi-channel digital signal processor and transmitter (DSPT),  
the DSPT being of the type having an ECG channel and a phonocardiographic  
20 (PCG) channel, the DSPT being at least adapted to normally sense an electrical signal indicative of cardiac rhythm through the ECG channel, and to normally sense heart sounds through the PCG channel, and to transmit signals to an external receiver,  
the method comprising the steps of:  
operatively connecting the DSPT bipolar ECG lead to a patient's heart; and  
25 operatively connecting the DSPT microphone to the patient's heart,  
whereby, after detecting an R-wave via the ECG channel, the DSPT issues a R-wave signal to the heart assist device controller to control the timing of the pulsation of the heart assist device, and  
whereby, after detecting a heart sound via the PCG channel, the DSPT issues a  
30 heart sound signal to the heart assist device controller to control the timing of the pulsation of the heart assist device.
6. The method as claimed in claim 5, wherein the DSPT is adapted to normally sense heart sounds through the PCG channel in the range of 20-500 Hz.
7. The method as claimed in claim 5 or 6, wherein the DSPT is able to receive as

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well as transmit.

8. The method as claimed in claim 7, wherein the DSPT has parameter settings adjusted within ranges, for detecting the R-wave and the heart sounds, and for the output signals.

5 9. The method as claimed in any one of claims 5 to 8, wherein the ECG lead connected to the patient's heart is epicardial or endocardial or attached to an implanted heart assist device itself.

10 10. The method as claimed in any one of claims 5 to 8, wherein sensors for the collection of an ECG signal are embedded into the surface of a heart assist device applied to the heart or another part of the patient's body from which an ECG signal may be received.

11. The method as claimed in any one of claims 5 to 10, wherein the DSPT microphone is internal to the patient's body.

15 12. The method as claimed in claim 11, wherein the connection to the patient's heart is epicardial.

13. The method as claimed in claim 11, wherein the connection to the patient's heart is endocardial.

14. The method as claimed in claim 11, wherein the connection to the patient's heart is in the manner of a pacing lead.

20 15. The method as claimed in claim 11, wherein the connection to the patient's heart is attached to the implanted device itself.

16. The method as claimed in claim 11, wherein the connection to the patient's heart is located within 50 mm of the cardiac valves.

25 17. The method as claimed in claim 11, wherein the connection to the patient's heart is without the lung between the microphone and the patient's heart.

18. The method as claimed in any one of claims 5 to 8, wherein the microphone is positioned outside the body of the patient.

30 19. The method as claimed in claim 18, wherein the heart sounds and ECG control an external gas-driven extra-aortic balloon pump using an external microphone placed in the lumen of the extra aortic balloon or the gas line leading to the extra aortic balloon.

20. The method as claimed in claim 19, wherein the implanted gas line and balloon acts as a 'stethoscope', and heart sounds can be detected intermittently or continuously, and sent directly to a controller positioned outside the patient's body.

21. The method as claimed in claim 20, wherein a percutaneous ECG lead is used

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to directly transmit the ECG signal to the controller.

22. The method as claimed in claim 21, wherein the ECG lead is combined with the percutaneous gas line.

23. The method as claimed in claim 21, wherein the ECG lead is separate from the percutaneous gas line.

24. The method as claimed in claim 22 or 23, further including a releasable and sealable connection for the percutaneous gas line and the ECG lead under the skin.

25. The method as claimed in any one of claims 5 to 24, wherein the DSPT is able to receive signals from an external device to adjust digital signal processing variables within the DSPT for detecting R-wave and heart sounds.

26. The method as claimed in any one of claims 5 to 25, wherein the DSPT has a battery of sufficient life that the DSPT can be removed and replaced, independent of the cardiac sensing leads.

27. The method as claimed in any one of claims 5 to 25, wherein the DSPT has a rechargeable battery that can be recharged by induction, or Transcutaneous Energy Transfer (TET).

28. The method as claimed in any one of claims 5 to 27, wherein the DSPT can communicate directly with an implanted controller.

29. The method as claimed in claim 28, wherein the controller and the ECG and microphone are contained within the pump and the pump is positioned in the medial right chest, with one aspect of the pump (containing hermetically sealed microphone and ECG electrodes) against the right heart structures.

30. A dual channel DSPT configured for use in controlling the operation of a pulsatile heart assist device, the DSPT being of the type having an ECG channel and a phonocardiographic (PCG) channel, the DSPT being at least adapted to normally sense an electrical signal indicative of cardiac rhythm through the ECG channel, and to normally sense heart sounds through the PCG channel, and to transmit signals to an external receiver to control the timing of the pulsation of the heart assist device.

31. The DSPT as claimed in claim 30, wherein, signals are directly sent to an implanted controller.

32. The DSPT as claimed in claim 30 or 31, wherein the DSPT is adapted to normally sense heart sounds through the PCG channel in the range of 20-500 Hz.

33. The DSPT as claimed in claim 30, 31 or 32, wherein the DSPT is able to receive as well as transmit.

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34. The DSPT as claimed in any one of claims 30 to 33, wherein the DSPT has parameter settings adjustable within ranges, for detecting the R-wave and the Heart Sounds, and for the output signals.

35. The DSPT as claimed in any one of claims 30 to 34, wherein the DSPT has other  
5 channels for detecting aortic and left ventricular blood pressure and for movement of the aortic or ventricular walls, and signals from these channels can also be interpreted to control heart assist device functioning.

36. Means for controlling a co-pulsation or counter-pulsation heart assist device, the means including:

10 a co- or counter-pulsation heart assist device;

a controller for the heart assist device; and

a DSPT of the type at least adapted to normally sense an electrical signal indicative of cardiac rhythm through an ECG channel and a sound signal indicative of heart sounds S1 and/or S2 through a PCG channel, and to issue identifiable signals to the  
15 controller, in which the DSPT is set to issue pacing signals from the ventricular circuit at a minimum rate which is below a physiologically sensible rate in the event that the atrial circuit is unable to sense a rhythm signal from the patient's ventricle, and the controller is set to turn off the heart assist device in the event that the pacing signals that the controller receives from the DSPT are at a rate below a predetermined rate which is above the  
20 minimum rate.